PATENT
Attorney Docket No. ZCO-107CP2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT(S):	Bredt *et al.*		
SERIAL NO.:	10/650,086	GROUP NO.:	1714
FILING DATE:	August 26, 2003	EXAMINER:	Callie E. Shosho
TITLE:	THREE DIMENSIONAL PRINTING MATERIAL SYSTEM AND METHOD		

RESPONSE UNDER 37 C.F.R. §1.116
EXPEDITED PROCEDURE
ART UNIT 1714

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF JAMES BREDT, Ph.D.
UNDER 37 CFR 1.132

I, James Bredt, declare and state that:

1. I hold a Bachelor of Science degree in materials science and engineering, a Master of Science degree in mechanical engineering, and a Ph.D. in mechanical engineering from MIT. I am a co-founder of and currently employed by Z Corporation, the assignee of the instant patent application ("the '086 patent application") undergoing examination in the United States Patent and Trademark Office. My title is Chief Materials Scientist and my research responsibilities include the specification, design, and development of materials systems for use in three-dimensional printing.

2. Prior to making this Declaration, I have reviewed U.S. Patent No. 5,738,921 to Andersen et al. ("the '921 patent") and U.S. Patent No. 5,965,776 to Leppard et al. ("the '776 patent). I am also familiar with the prosecution history of the '086 patent application.

3. I am an inventor of the claimed subject matter in the '086 patent application, which is drawn to compositions for three-dimensional printing, kits for three-dimensional printing, and methods for three-dimensional printing. According to one embodiment, a particulate material suitable for use in three dimensional printing includes a particulate adhesive material and plaster.

4. I understand that certain claims pending in the '086 patent application have been rejected based upon the '921 patent. Specifically, I understand the Examiner has taken the positions (i) that the claimed composition of a particulate mixture including an adhesive and plaster is disclosed by the '921 patent and (ii) that there is no evidence of record showing that the composition of the '921 patent is not suitable for use in three dimensional printing.

5. I also understand that certain claims pending in the '086 patent application have been rejected based upon the '776 patent. Specifically, I understand the Examiner considers the stereolithographic compositions of the '776 patent to be anticipatory to the particulate compositions suitable for three dimensional printing that are claimed in the '086 patent application. I also understand that the Examiner has requested clarification regarding where the '776 patent discloses the use of aqueous dispersions and other fluids, as stated by the Applicants' attorney in an Amendment and Response filed on September 29, 2005.

6. Based on my review of the '921 patent, it is clear to me that the compositions described in the '921 patent are moist and, therefore, are not suitable for use in three dimensional printing.

7. The materials used in the process disclosed in the '921 patent may be in one of two forms, neither of which is suitable for three dimensional printing: (i) inorganically filled mixture prepared prior to a forming operation or (ii) an intermediate material prepared in sheet form using the inorganically filled mixture as a raw material, the sheet form later being subjected to another forming operation to create the finished article. *See* column

11, lines 14-25 and column 20, lines 47-60. Regarding the former, "when the inorganically filled mixture is directly molded, it will maintain its shape..." *See* column 11, lines 14-16. The latter form is characterized as follows: "the green inorganically filled sheet will have sufficient cohesive strength such that it will maintain integrity as a sheet as it processes from one set of rollers to the next..." *See* column 11, lines 19-22.

8. The Examiner refers to passages in the '921 patent that discuss the addition of water to or removal of water from the inorganically filled mixture (i.e., column 24, lines 36-38 and column 30, lines 63-67) and, therefore, appears to suggest that the first form of the material is equivalent to the claimed compositions in the '086 patent application. As noted throughout the '921 patent, however, the inorganically filled mixture includes water. *See*, e.g., column 20, lines 58-60. In fact, the inorganically filled mixture must include a minimum amount of moisture, below which the material is considered hardened and, therefore, not formable. The '921 patent discloses that "[i]n order for the mixture to have adequate workability, water must generally be included in quantities sufficient to wet each of inorganic aggregate particles, fibers, or other solid particles, to gelate, solvate, or at least disperse the organic binder, and to at least partially fill the interstices or voids between the solids." *See* column 23, lines 57-62.

9. The inorganically filled mixture that includes water has a high magnitude of cohesion. More particularly, "[t]he yield stress of the inorganically filled mixtures of the present invention will preferably be in a range from about 2 kPa to about 5 MPa ... most preferably in a range from about 200 kPa to about 700 kPa." *See* column 24, lines 10-15. The lower limit of the most preferable level of yield stress is about 30 psi in English units; the lower limit of the preferable level of yield stress is about 0.3 psi. While this is not a "strong" material in the strictest sense of the word, it is emphatically not a free-flowing powder that could possibly be distributed by a counter-roller in a three dimensional printing machine, such as the machines manufactured by Z Corporation, the

assignee of the '086 patent application. A material with the yield strength described in the '921 patent is clearly not suitable for three dimensional printing.

10. As support for the above conclusion, I note that a yield strength may be illustrated by a height of a pile of powder in which a pressure at the bottom of the pile is the same magnitude as the yield stress of the material. The '921 patent discloses a bulk density of "greater than about 0.5 g/cm^3." *See* column 12, lines 17-18. Using an estimated bulk density of 1.0 g/cm^3 (consistent with the particulate mixtures used by Z Corporation for three dimensional printing), a yield strength of 30 psi would permit a pile roughly sixty-seven feet tall to be built before the pressure at the bottom exceeded the yield strength. Even at the lowest estimate disclosed in the '921 patent (2 kPa or 0.3 psi), the pile would be about eight inches tall. By contrast, a bead of powder spread by a 3D printer during three dimensional printing is approximately ½ inch tall. For that pile to be drawn out into a thin layer during the spreading process, the yield strength must accordingly be lower than 0.125 kPa, or about one sixteenth of the lowest yield stress admissible by the '921 patent. In fact, the '921 patent refers to a body of this material as "a blob or other unstructured mass" and not as a "particulate material." *See* column 43, lines 59-61.

11. To achieve the requisite low yield strengths, it is necessary that there be substantially no water in the granular materials manufactured by Z Corporation and disclosed in the '086 patent application that are suitable for three dimensional printing. On the other hand, in order for the mixture of the '921 patent to have sufficiently high yield strength to maintain its shape after molding, it is necessary for there to be "as little as 5% to as high as 80% by weight" of water at the time of the forming operation. *See* column 24, lines 37-38. Evaporation of the moisture from the molded articles hardens them to form an "inorganically filled matrix" with a strength "up to about 40 – 50 MPa" or around 6000-7000 psi. *See* column 30, lines 63-67, column 21, lines 14-21, and column 22, lines 29-36.

12. The '921 patent describes combining the components of inorganicially filled mixtures with water as follows. First, a gel or suspension is made by mixing together a binder and water. Then, fibrous materials and fillers are added to the gel or suspension. *See* column 37, lines 30–41. Thus, at no point does the '921 patent describe a particulate mixture including plaster and an adhesive that is suitable for three dimensional printing.

13. For the reasons discussed above, the fact that the inorganically filled mixture of the '921 patent includes water renders it unsuitable for three dimensional printing. In order to achieve the requisite low yield strengths, it is necessary that there be no water in the particulate material to be used for three dimensional printing, such as the granular materials manufactured by Z Corporation and disclosed in the '086 patent application.

14. The '921 patent uses the term "inorganically filled mixture" to describe the raw material before forming (that contains at least 5% moisture and has a yield strength of at least 2 kPa) and the term "inorganically filled matrix" to describe the material after forming and subsequent drying, with a strength tens or even hundreds of times higher, and an impermeable structure that permits the finished article to act as a container for liquids.

15. Returning to the second form of raw material for forming the finished articles in the '921 patent, the discussion of the physical properties is confined to a brief mention, indicating that the sheets contain free voids. *See* column 11, line 61 – column 12, line 20.

16. The '921 patent discloses forming articles from moist sheets. *See* column 43, line 53 – column 48, line 7. Clearly, if a sheet is "wet," it must be considered to contain moisture. In the dry-sheet process, each "dry" sheet is initially formed as a "wet" sheet and then dried. *See* column 48, line 10 – column 50, line 22. The forming process may involve several rolling operations that include drying. The '921 patent discloses, however, that "if further reductions in sheet thickness are to be made by subsequent reduction rollers, the sheet must exit each preceding set of reduction rollers with sufficient moisture so that the sheet will not be damaged when further reduced in thickness." *See* column 48, lines

34-38. The '921 patent describes extensively the sophisticated temperature control necessary to prevent the sheets from drying too soon in the manufacturing process. *See* column 49, line 10 – column 51, line 9. Moreover, "[a]t some point the inorganically filled sheet can become so dry and hard that the matrix cannot be compressed without fracturing." *See* column 51, lines 48-50.

17. The sheets manufactured by these processes are impermeable. This is an essential property for the bottles and cartons that Andersen wishes to produce. *See*, e.g., column 6, lines 33-38. The sheet material is compacted by rolling to remove voids. *See* column 51, lines 29-31.

18. Particulate material that is suitable for three dimensional printing is not impermeable; rather, it is porous. The three dimensional printing technology described in the '086 patent application and used by Z Corporation in all of its products utilizes an inkjet printhead to deliver a liquid or colloidal binder to layers of powdered material. In this process, "[t]he [liquid or colloidal] binder infiltrates into the gaps in the powdered material, hardening to bond the material to a solidified layer." See page 3, lines 2-3 of the '086 patent application, referring to a three dimensional printing process (3DP™) described in U.S. Patent No. 5,204,055 and used by Z Corporation. In other words, the powdered materials used in a Three Dimensional Printer form a porous substrate for the printing operation, and the fluid deposited from above must permeate the porous layers to initiate the binding of the grains of powder to form a continuous network.

19. It is difficult to envision any process in which a stack of the impermeable sheets disclosed in the '921 patent may be bonded by depositing a liquid that causes the sheets to adhere one atop the other. Further, this process does not provide any means to remove the untreated sheet material and extract the formed article. If this article could be formed, it would be necessary at the end of the process to fracture all of the unbound portions of sheets in the stack to expose the bonded edges of the manufactured article. On the other hand, the use of granular materials in three-dimensional printing processes makes this

unnecessary: unbound powder may be blown or brushed off the part provided it has a sufficiently low yield strength. As noted above, a sufficiently low yield strength in the powder is obtained by manufacturing the granular material without moisture.

20. Accordingly, the dried sheets described in the '921 patent are impermeable and not equivalent to particulate materials; these sheets are unusable for three dimensional printing.

21. In summary, the compositions of the '921 patent are either moist or impermeable and, therefore, are not suitable for use in three-dimensional printing.

22. With reference to the '776 patent, aqueous dispersions are discussed, for example, in column 16, line 44 – column 17, line 35. The '776 patent also mentions fillers and/or pigments. *See*, e.g., column 16, lines 34 - 39 and column 17, lines 22 - 30. Along with pigments and fillers, the lists of chemicals include dispersants, emulsifiers, wetting agents and thickeners, making it clear that the disclosed subject matter includes dispersion of solid fillers and pigments in a liquid phase. Aqueous dispersions are not equivalent to dry particulate materials suitable for three dimensional printing, for the reasons discussed above.

23. Further evidence that the materials disclosed in the '776 patent are not suitable for three dimensional printing is the fact that suggested uses for the disclosed materials are inks, paints, varnishes, adhesives, and coatings in general. *See* column 19, lines 36-61. Moreover, stereolithography is mentioned in passing. As is well known in the art, stereolithography is a process by which material is distributed in liquid form, in contrast to three dimensional printing, in which materials are distributed in dry particulate form.

24. The '776 patent mentions powders only in the context of powder coating. *See*, e.g., column 19, lines 60-61 and column 20, lines 11 - 63. Powder coating is a process in which a polymeric coating material possesses a melting point of a slightly elevated temperature, and the material can be prepared as a powder. The powder is sprayed onto a

substrate, and is melted onto the substrate in a thin coating. The coating is cured by further heating, and in the case of the invention of the '776 patent, by further application of UV radiation. More particularly, "[t]he process normally comprises electrostatic or tribostatic spraying of the powder onto the substrate .... melting the powder by heating and, after a smooth film has been formed, radiation-curing the coating using ultraviolet and/or visible light..." *See* column 20, lines 34 - 40. This process is very different from three dimensional printing and requires significantly different types of material. Here the bonding of the powder grains occurs only after the polymeric powder is melted by heat, and a solid substrate is required to support the coating. Furthermore, the use of radiation to cure the coating essentially limits the powder-forming operation to that of a thin coating: light can penetrate the material only to a small depth, especially if pigments are used. In contrast, particulate mixtures suitable for three dimensional printing claimed in the '086 patent application are bonded together by application of a binder, rather than by heat. Moreover, in three dimensional printing, particles are joined together to form an article, rather than being a coating formed on a substrate made of a different material. Finally, an additional distinction between the powders of the '776 patent and the particulate material that is the subject of the invention of the '086 patent application is that the former powders do not include plaster, as required by the '086 patent application.

25. In summary, the liquid dispersions of the '776 patent are not suitable for use in three dimensional printing, which requires dry particulate material. Also, the only powders disclosed by the '776 patent are for coating and are distinguishable in several ways from particulate material suitable for three dimensional printing.

26. I further declare that all statements made in this Declaration of my own knowledge are true and that all statements made on information and belief are believed to be true. Moreover, these statements are made with the knowledge that willful false statements and the like made by me are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may

jeopardize validity of any patent issuing based on U.S. Patent Application Serial No. 10/650,086.

Date: 2/28/04

By: _____
James Bredt, Ph.D.